COLD RECYCLING OF BITUMINOUS MATERIAL (PARTIAL DEPTH) MSP-03-04

1.0 Description. This work shall consist of milling, crushing and screening the in-place bituminous material to the depth and width shown on the plans. An emulsified asphalt binder agent, hydrated lime slurry, water and other additives, if required, shall be incorporated into the milled material. The combined material shall be spread and compacted in accordance with the plans and specifications and as directed by the engineer. This process will be referred to as Cold In-Place Recycling (CIR).

2.0 Material. All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

Item	Section
Emulsified Asphalt	1015
Water	1070

2.1 Asphalt Emulsion. The type of asphalt emulsion to be used shall be determined by the mixture design. A specific product name shall be furnished for each emulsion provided. A representative from the asphalt emulsion supplier shall be on the job site at the beginning of the project to monitor the characteristics and performance of the asphalt emulsion. Throughout the job, the representative shall be available to check on the project and make adjustments to the asphalt emulsion formulation as required.

2.2 Coldmilled Material. The compacted product shall be placed at a thickness of a minimum of 2.5 inches (63 mm) and to a maximum of 6 inches (150 mm.) The cold pulverized material shall meet the following gradation prior to the addition of the asphalt emulsion:

Sieve Size	% Passing by Weight
1.25 in. (31.5mm)	100

2.3 Hydrated Lime Slurry. The hydrated lime slurry shall be manufactured at the jobsite by slaking pebble quicklime. Pebble quicklime shall be in accordance with AASHTO M 216, Lime for Soil Stabilization. Each load of quicklime shall be accompanied by a certification stating the purity for that load.

2.4 Other Additives. If necessary, additives may be used to produce a mixture in accordance with Section 3.0. The type and percentage used shall be described in the submitted design recommendation.

3.0 Mixture Design. The contractor using material obtained directly from the project site shall submit a mix design tested in accordance with Appendix 1. Based on cores taken before the project, more than one mix design may be required. The job mix formula shall be submitted to Construction and Materials for approval and shall not be used prior to receiving that approval. Mix design procedures for CIR shall be in accordance with Appendix 1. Specimens shall be

prepared in 4-inch (100 mm) diameter molds, unless otherwise specified, with a Superpave Gyratory Compactor (SGC.) The mixture shall meet the following criteria at the selected design asphalt emulsion content:

Property	Criteria
Compaction effort, SGC	1.25° angle, 600 kPa stress, 30 gyrations
Density, AASHTO T 166	Report
Gradation for Design Millings, AASHTO T 27	Report
Marshall Stability [a], AASHTO T 245 Section 4, 40 C	1,250 lb (5.56 kN) min.
Retained stability based on cured stability, Appendix 1	70 % min.
Indirect Tensile Test, AASHTO T 322, Modified in Appendix 2	See Note in Appendix 2
Raveling Test, Method Attached, 10 C and 50% humidity, Appendix 3	2% max.

[a] Cured stability tested on compacted specimens after 140 F (60 C) curing to constant weight (mass).

3.1 Lime Slurry. Lime slurry shall be added at a rate of 1.5% calcium oxide (quicklime) by mass of the milled material.

3.2 Asphalt Emulsion. Asphalt emulsion shall be in accordance with Sec 1015 and the following requirements:

Test	Specification	Minimum	Maximum
Residue from distillation, %	AASHTO T 59 [a]	64.0	66.0
Oil distillate by distillation, %	AASHTO T 59 [a]		0.5
Sieve Test, %	AASHTO T 59 [a]		0.1
Penetration (TBD [b]), 25°C, dmm	ASTM D5	-25%	+25%

[a] Modified AASHTO T59 procedure – distillation temperature of 350 F (177 C) with a 20 minute hold. The ASTM D 244 vacuum distillation procedure may be substituted once the maximum oil distillate is satisfied.

[b] TBD shall be determined by the CIR design prior to emulsion manufacture for the project. Penetration range shall be determined on the design requirements for the project and shall be submitted to Construction and Materials for approval prior to project start.

4.0 Equipment.

4.1 Milling Machine. A self-propelled coldmilling machine that is capable of pulverizing the existing bituminous material in a single pass to the depth shown on the plans and to a minimum width of no less than 12.0 feet (3.6 m) shall be used. The machine shall have automatic depth controls to maintain the cutting depth to within ±0.25 inch (6 mm) of that shown on the plans and shall have a positive means for controlling cross slope elevations. The milling chamber shall have one or more spray bars to incorporate hydrated lime slurry and water into the Recycled

Asphalt Pavement (RAP.) The use of a heating device to soften the pavement will not be permitted.

4.2 Lime Slurry Plant. Equipment specifically designed for production of lime slurries shall be used. Agitating equipment shall be used to keep the hydrated lime slurry in suspension during transport.

4.2.1 Lime Metering. Introduction of the lime slurry shall be at the mill head by mass of the coldmilled material. The mass of the coldmilled material shall be calculated by lb/ft3 (kg/m3) for volume of cut. A metering device shall be used to accurately measure the amount of lime slurry required to within plus or minus five percent. Lime slurry rate of application shall be tied to the forward speed of the milling machine.

4.2.2 Lime Feed Tank. Agitators or similar equipment shall keep the hydrated lime slurry in suspension when held in the lime slurry feed tank.

4.3 Crushing Machine. A material sizing unit shall have screening and crushing capabilities to reduce the pulverized bituminous material to the size required by Section 2.2 prior to mixing with asphalt emulsion. The screening and crushing unit shall have a closed circuit system capable of continuously returning oversized material to the crusher. All of the RAP shall be processed to meet the gradation in accordance with Section 2.2.

4.4 Mixing Unit. The mixing unit shall be an on-board, completely self-contained pugmill equipped with a belt scale for the continuous weighing (determination of mass) of the pulverized and sized bituminous material and a coupled/interlocked computer controlled liquid metering device. The liquid metering device shall be capable of automatically adjusting the flow of asphalt emulsion to compensate for any variation in the weight (mass) of pulverized material coming into the mixer. The metering device shall deliver the amount of asphalt emulsion to within $\pm$ 0.2 percent of the required amount by weight (mass) of pulverized bituminous material. The asphalt emulsion pump shall be of sufficient capacity to supply emulsion contents up to 3.5 percent by weight (mass) of pulverized bituminous material. Automatic digital readings shall be displayed for both the flow rate and total amount of pulverized bituminous material and asphalt emulsion in appropriate units of weight (mass) and time. The mixing unit shall be capable of processing the pulverized material and asphalt emulsion and water to a homogeneous mixture.

4.5 Pick-up Machine. A pick-up machine may be used for transferring the recycled material from a windrow to the receiving hopper of the bituminous paver. The pick-up machine shall be capable of removing the entire windrow down to the remaining underlying material without segregation.

4.6 Paver. A self-propelled conventional bituminous paver having electronic grade and cross slope control for the screed shall be used. The equipment shall lay the mixture in one smooth continuous pass to the specified section and as shown on the plans. Alternatively to the equipment listed in Sections 4.3, 4.4 and 4.5, a self-propelled paver with on-board pugmill and emulsion tank may be used. Millings shall be added directly to the hopper. The paver shall be equipped with a belt scale for the continuous weighing (determination of mass) of the pulverized and sized bituminous material and a coupled/interlocked computer controlled liquid metering device. The mixing unit shall be an on-board completely self-contained pugmill. The liquid metering device shall be capable of automatically adjusting the flow of asphalt emulsion to

compensate for any variation in the weight (mass) of pulverized material coming into the mixer. A metering device in accordance with Section 4.4 shall deliver the asphalt emulsion.

4.7 Rollers. All rollers shall be self-propelled. The number, weight (mass) and types of rollers shall be as necessary to obtain the required compaction. At least one pneumatic roller shall have a minimum gross operating weight (mass) of no less than 50,000 lbs. (22,600 kg). At least one double drum vibratory roller shall have a gross operating weight (mass) of no less than 20,000 lbs. (9,000 kg) and a width of no less than 78 inches (1980 mm). Rollers shall have properly working scrapers and water spraying systems. Diesel fuel, fuel oil or other detrimental products shall not be used as wetting agents.

4.8 Broom. A self-propelled power broom for removal of loose particles and other material from the CIR surface shall have positive control on the downward pressure applied to the surface.

5.0 Construction Methods.

5.1 Weather Limitations. Cold in-place recycling operations shall be completed when the atmospheric temperature measured, in accordance with MoDOT Test Method TM-20, is 50 F (10 C) and rising. All equipment shall be off the road 30 minutes before sunset. The weather shall not be foggy or rainy and shall not call for freezing temperatures within 48 hours after placement of any portion of the project.

5.2 Vegetation Removal. Grass and other vegetation shall be removed from the edge of the pavement to be milled to prevent contamination of the pulverized bituminous material during the milling operation.

5.3 Milling. The existing pavement shall be milled to the required depth and width as shown on the plans. Recycling shall be in a manner that does not disturb the underlying material in the existing roadway. The milling operation shall be conducted so that the amount of fines occurring along the vertical faces of the cut will not prevent bonding of the cold recycled material. The pulverized bituminous material shall be processed by crushing and screening to the required gradation in accordance with Section 2.2.

5.4 Mixture Adjustment. The asphalt emulsion and water shall be incorporated into the pulverized bituminous material at the initial rate determined by the mix designs and approved by the engineer. The total water content shall include that amount added at the milling head and added at the mixing unit. Different levels of asphalt emulsion may be determined by the mix design at various portions of the project.

5.5 Spreading. The recycled material shall be spread in one continuous pass, without segregation and to the lines and grades as shown on the plans or as directed by the engineer. When using a pick-up machine, the pick-up machine shall be within 150 feet (45 m) of the mixing unit described in Section 4.4.

5.6 Compaction. Compaction of the recycled mix shall be completed using rollers in accordance with Section 4.7. Rolling patterns shall be established to achieve a maximum density determined by nuclear density testing. Rolling shall be continued until no displacement is occurring or until the pneumatic rollers walk out of the mixture. Double drum steel rollers, either operating in a static or vibratory mode, shall be used for final rolling to eliminate pneumatic tire

marks and to achieve density. Vibratory mode shall only be used if it is shown to not damage the pavement. The selected rolling pattern shall be followed unless changes in the recycled mix or placement conditions occur and a new rolling pattern is established at that time. Rolling or roller patterns shall change when major displacement or cracking of the recycled material is occurring. Rolling shall start no more than 30 minutes behind the paver. Finish rolling shall be completed no more than one hour after milling is completed. When possible, rolling shall not be started or stopped on uncompacted material. Rolling patterns shall be established so that the rolling patterns begin or end on previously compacted material or the existing pavement.

5.7 Release to Traffic. After compaction of the recycled material, no traffic, including the contractor's, shall be permitted on the completed recycled material for a minimum of two hours. After two hours, rolling traffic may be permitted on the recycled material. This time may be adjusted to allow establishment of sufficient cure so traffic will not initiate raveling. After opening to traffic, the surface of the recycled pavement shall be maintained in a condition suitable for the safe movement of traffic. While the roadway is open to traffic and the CIR is the riding surface, all loose particles that may develop on the pavement surface shall be removed by power brooming or other approved methods.

5.8 Damage. Any damage to the completed CIR bituminous material shall be repaired by the contractor prior to the placement of the hot mix asphalt concrete surface course, or other applicable surface treatment, and as directed by the engineer. Damage unrelated to contractor construction procedures or quality of work, such as due to poor base conditions, will be considered Recycled Material Patching and paid in accordance with Section 8.0. Patching material shall be prepared in accordance with Section 5.0 or Sec 401.

5.9 Smoothness. The completed cold recycled material surface shall not vary more than 0.25 inch (6 mm) from the lower edge of a 10-foot (3-meter) straight edge placed on the surface parallel and transversely to the centerline.

5.10 Curing. Before placing the hot mix asphalt concrete surface course, or other applicable surface treatment, the CIR bituminous material shall be allowed to cure until the moisture of the material is reduced to 2.0 percent or less, or to a level approved by the engineer. Under dry conditions the CIR should meet the moisture requirements within 48 hours. Moisture determination shall be made in accordance with Section 4.0 of Appendix 1.

6.0 Quality Control. The contractor shall be responsible for quality control of the materials and cold recycling process.

6.1 Pulverized Bituminous Material Sizing. A sample shall be obtained each 0.5 mile (0.8 km) before adding emulsion and screened using a 1.25 in. (31.25 mm) sieve (or smaller sieve if required) to determine if the pulverized bituminous material is meeting the maximum particle size requirement. In addition, two gradations shall be performed each day on the moist millings using the following sieves: 1.25 (31.25 mm) inch, 1.0 inch (25.0 mm), 3/4 inch (19.0 mm), 1/2 inch (12.5 mm), 3/8 inch (9.5 mm), No. 4 (4.75 mm), No. 8 (2.36 mm), No. 16 (1.18 mm), and No. 30 (600 µm). The resulting gradation shall be compared to the mix design gradations to determine any necessary changes to the emulsion content. Sampling procedures shall be in accordance with AASHTO T 168.

6.2 Asphalt Emulsion. The asphalt emulsion shall be received on the job site at a temperature no greater than 120 F (50 C). Samples to be tested by the engineer will be obtained from the shipping trailers prior to unloading into the contractor's storage units.

6.3 Asphalt Emulsion Content. Emulsion content shall be checked and recorded for each segment in which the percentage is changed. Emulsion content changes shall be made based upon mix design recommendations, which are based upon different mix designs for road segments of varying construction. Asphalt emulsion content shall be determined by readings from the belt scale totalizer and asphalt pump totalizer.

6.4 Water Content. Water content at the milling head shall be checked and recorded for each segment in which the percentage is changed. This information shall be gathered from the water-metering device, which shall be checked from the belt scale totalizer to verify daily quantities used. Water content changes shall be made based on mixture consistency, coating and dispersion of the recycled material.

6.5 Lime Content. Lime content at the milling head shall be checked and recorded for each segment in which the percentage is changed. This information shall be gathered from the shipping tickets and lime-metering device and shall be checked with the belt scale totalizer to verify daily quantities used.

6.6 Mixture Testing. Samples shall be gathered for mixture testing for Marshall Stability and Retained Stability at a frequency of one test per two lane miles (3.2 km.) The samples shall be taken in accordance with AASHTO T 168 and T 248. The specimens shall be compacted within 30 minutes of sampling and tested in accordance with Section 3.0. The samples shall be screened through a 1-inch (25.0 mm) screen for 4-inch (100 mm) specimens. If the Marshall Stability is below 1100 pounds (4.89 kN) or the Retained Stability is below 60 percent, production shall be halted until a new mix design is developed and approved by Construction and Materials. In lieu of blended samples, samples of the pulverized bituminous material prior to introduction of the emulsion may be taken and blended with field emulsion and tested in accordance with Section 3.0. Samples taken in this manner shall be sealed in a plastic container to prevent the loss of moisture and shall be mixed with the field emulsion within 24 hours of sampling.

6.7 Depth of Milling. The nominal depth shall be checked on both outside vertical faces of the cut each 500 feet (150 m).

6.8 Recycled Material Compacted Density. A wet density shall be determined using a nuclear moisture-density gauge in accordance with MoDOT Test Method TM-41, backscatter measurement. A rolling pattern shall be established so that a maximum density is achieved with the rollers specified, based on relative nuclear density readings. Maximum density will be considered to be when the relative density changes less than 10 pcf (160 kg/m^3) between passes. Care shall be taken not to over-roll the mat based on visual observations of check cracking or shoving. A new rolling pattern shall be established if the material being recycled changes.

7.0 Method of Measurement. Work as described for this item will be measured to the nearest 0.1 square yard (0.1 m^2) of the completed sections for the depth specified. Final measurement will not be made except for changes authorized by the engineer. Measurement of asphalt emulsion to the nearest 10 gallons (50 L) will be made as specified in Sec 1015. If water is

added to asphalt emulsion, the quantity to be paid for will be determined prior to the addition of water. Recycled Material Patching will be measured to the nearest 0.1 ton (0.1 Mg).

8.0 Basis of Payment. The accepted quantities of CIR, asphalt emulsion and recycled material Patching will be paid for at the unit prices for each of the pay items included the contract. An emulsion content of three percent by weight (mass) of the milled bituminous material will be used for bidding purposes prior to the completed design.

APPENDIX 1 - Mix Design Procedures for Cold In-Place Recycling (CIR) Material

1.0 Sampling and Processing. Cores shall be obtained from the areas to be recycled. If cores show significant differences in various areas, such as different type or thickness of layers between cores, then separate mix designs shall be performed for each of these pavement segments. At a minimum, one core shall be taken for each lane mile and where visual differences in the pavement are noticed. Cores shall be cut in the laboratory to the depth specified for the CIR project. Cores shall be crushed in the laboratory. A mix design shall be perform using the medium gradation and a minimum of one of the fine or coarse gradations using the following recycled asphalt pavement millings criteria.

	Percent Passing by Weight		
Sieve Size	**Fine**	**Medium**	**Coarse**
1 1/4 in. (31.25 mm)	100	100	100
1 in. (25.0 mm)	100	100	85 - 100
3/4 in. (19.00 mm)	95 - 100	85 - 96	75 - 92
No. 4 (4.75 mm)	55 - 75	40 - 55	30 - 45
No. 30 (600 µm)	15 - 35	4 - 14	1 - 7
No. 200 (75 µm)	1 - 7	0.6 - 3	0.1 - 3

1.1 The mix design shall be performed on these crushed millings. Gradation of the millings after crushing shall be determined by AASHTO T 11 and T 27 (dried at no greater than 40 C.)

1.2 Samples shall be prepared with a sample splitter. An alternative method is to dry, screen and recombine millings in the laboratory to target gradation. Oversize shall be scalped with a 1-inch (25.0 mm) screen when using 4-inch (100 mm) diameter compaction molds.

2.0 Mixing. The specimen size shall produce a 2.4 to 2.6 inch (61.0 mm to 66.0 mm) tall specimen. The size for Rice specific gravity specimens shall be in accordance with AASHTO T 209.

2.1 Four specimens shall be compacted per emulsion content for a total of six for long-term stability and six for moisture testing. Two specimens shall be required for Rice specific gravity; test at the highest emulsion content in the design and back calculate for the lower emulsion contents.

2.2 The recommended emulsion contents shall be 1.5 percent, 2.0 percent, 2.5 percent, 3.0 percent, 3.5 percent and 4.0 percent. Three emulsion contents shall be chosen that bracket the estimated recommended emulsion content.

2.3 Moisture that is expected to be added at the milling head shall be added to the mix, typically 1.5 – 2.5 percent and lime slurry at a 1.5 percent by weight (mass) of quicklime.

2.4 Other additives shall be introduced in a similar manner, in the order as the additives will be introduced during field production.

2.5 Mixing of test specimens shall be performed with a mechanical mixer that provides uniform coating of the mixture. The RAP millings shall be thoroughly mixed with lime slurry and water first, then mixed with emulsion. Mixing shall occur at ambient temperature. One specimen shall be mixed at a time. Mixing time with emulsion shall not exceed 60 seconds.

3.0 Compaction. Specimens shall be compacted immediately after mixing with a Superpave gyratory compactor (SGC) in a 4-inch (100 mm) mold at 1.25 degree angle, 600 kPa ram pressure, and 30 gyrations. Paper disks shall be placed on the top and bottom of the specimen before compaction. The mold shall not be heated.

4.0 Curing After Compaction. Specimens shall be extruded from molds immediately after compaction, carefully removing the paper disks.

4.1 Specimens shall be placed in a 140 F (60 C) forced draft oven with ventilation on sides and top. Each specimen shall be placed in a small container to account for material loss from the specimens.

4.2 Specimens for Rice specific gravity shall be dried to constant mass (less than 0.05 percent mass loss in two hours). Care shall be taken not to over-dry the specimens.

4.3 Compacted specimens shall be cured to constant mass but no more than 48 hours and no less than 16 hours. Constant mass will be defined here as 0.05 percent change in mass in two hours. After curing, specimens shall be cooled at ambient temperature a minimum of 12 hours and a maximum of 24 hours.

5.0 Measurements. The bulk specific gravity (density) shall be determined for each compacted (cured and cooled) specimen in accordance with AASHTO T 166. The mass of the specimen in water (measurement C) may be recorded after one minute of submersion.

5.1 Specimen heights shall be determined in accordance with ASTM D 3549. Alternatively, the height may be obtained from the SGC readout.

5.2 Rice specific gravity (maximum theoretical) shall be determined in accordance with ASSHTO T 209, except as noted in Section 4.0 of Appendix 1 and as follows. Any agglomerates which will not easily reduce with a flexible spatula shall not be broken. The supplemental dry-back procedure shall be performed to adjust for uncoated particles.

5.3 Air voids shall be determined at each emulsion content.

5.4 The corrected Marshall stability in accordance with AASHTO T 245 at 104 F (40 C) after two hour temperature conditioning in a forced draft oven shall be determined. This testing shall be performed at the same time that the moisture-conditioned specimens are tested.

6.0 Moisture Susceptibility. The same conditioning and volumetric measurements shall be performed on moisture-conditioned specimens as on other specimens. Saturate specimens shall be vacuumed to 55 to 75 percent of the dry mass and then shall be soaked in a 77 F (25 C) water bath for 23 hours. This soaking shall be followed by a one-hour soak at 104 F (40 C). The corrected Marshall stability shall then be determined. The average moisture conditioned

specimen strength divided by the average dry specimen strength will be referred to as retained stability.

7.0 Thermal Cracking. Critical cold temperature selection shall be determined in accordance with Appendix 2.

8.0 Raveling. The susceptibility of the mix to raveling shall be determined in accordance with Appendix 3.

8.0 Emulsion Content Selection. The properties of the specimens at design emulsion content shall meet the properties of CIR.

9.0 Report. The mixture design report shall contain the following minimum information:

(a) Gradation of RAP.
(b) Amount and gradation of virgin aggregate or additional RAP, if any.
(c) Recommended water content range as a percentage of dry RAP.
(d) Optimum emulsion content as a percentage of dry RAP and corresponding density, air void level and absorbed water.
(e) Marshall stability and retained stability at recommended moisture and emulsion contents, raveling percent and thermal cracking initiation temperature.
(f) The emulsion designation, company name, plant location and the following emulsion properties: residue content, oil distillate, sieve retainage and penetration.

APPENDIX 2 – Procedures for Performing AASHTO T 322 for CIR Design Specimens

1.0 The required specification temperature for AASHTO T 322 shall be the critical cold temperature for the project. The critical cold temperature shall be determined by using FHWA LTPPBind software (Version 2.1) and the weather station closest to the project. The required specification temperature for AASHTO T 322 will be the coldest temperature at the top of the CIR layer in the pavement structure, using 98 percent reliability.

2.0 The indirect tensile testing (IDT) shall be performed in accordance with AASHTO T 322, with the following exceptions.

2.1 Specimens using the medium gradation shall be 150 mm in diameter and at least 115 mm in height and compacted to air voids +/- one percent of design air voids at the design emulsion content. A trial specimen is suggested for this. Test specimens shall be cured at 60 C no less than 48 hours and no more than 72 hours. Specimen mass shall be checked every two hours after 48-hour cure to check with compliance of no more than 0.05 percent change in mass in two hours. After curing, two specimens shall be cut from each compacted specimen to 50 mm in height. Bulk specific gravity shall be performed after cutting.

2.2 Instead of three specimens, two specimens shall be the minimum required at each of the three temperatures.

2.3 Two temperatures shall be selected at 10 C intervals that bracket the required specification temperature. For example, if the required specification temperature is -25 C, then select testing temperatures of -20 C and -30 C. A temperature of -10 C or -40 C shall then be selected to complete the third required temperature.

2.4 The tensile strength test shall be carried out on each specimen directly after the tensile creep test at the same temperature as the creep test.

2.5 The environmental chamber shall be capable of temperatures down to -40 C.

2.6 The critical cracking temperature will be at the intersection of the calculated pavement thermal stress curve (derived from the creep data) and the tensile strength line (the line connecting the results of the average tensile strength at the two temperatures).

APPENDIX 3 – Procedures for Performing the Raveling Test on Recycled Asphalt Specimens

1.0 The apparatus used for the raveling test shall be a modified A-120 Hobart mixer and abrasion head (including hose) used in the Wet Track Abrasion of Slurry Surfaces Test (ISSA TB-100). The rotation speed for the raveling test will not be modified from ISSA TB-100. The ring weight shall be removed from the abrasion head for the raveling test below. The mass of the abrasion head and hose in contact with the specimen shall be 600 +/- 15g. The prepared sample shall be able to be secured under the abrasion head, and centered for accurate result, allowing for free movement vertically of the abrasion head. The device used for securing and centering the sample shall allow a minimum of 10 mm of the sample to be available for abrasion. The Hobart mixer shall be modified to allow the sample to fit properly for abrasion. The modification may be accomplished by adjusting the abrasion head height or the height of the secured sample. A Raveling Test Adapter may be purchased through Precision Machine and Welding, Salina, KS, (785) 823-8760. The Hobart Model number A-120 will need to be referenced when ordering. The C-100 and N-50 Models will not be acceptable for this test procedure due to differences in size and speed of rotation.

2.0 The raveling test on recycled specimens shall be performed as follows:

2.1 Two recycled asphalt samples shall be split out from the medium gradation to a mass of 2700 g. (The 2700 g is an approximate mass to give 70 +/- 5 mm of height after compaction.) Alternatively, two field mix samples may be used, in which case, Steps 2, 3 and 4 will not be applicable.

2.2 The recycled asphalt sample shall be placed in a container of adequate size for mixing.

2.3 Field or design moisture contents shall be added to each of the recycled asphalt samples and mixed for 60 seconds.

2.4 The design emulsion content shall be added to each of the recycled asphalt samples and mixed for 60 seconds.

2.5 The samples shall be placed immediately into a 150 mm gyratory compaction mold and compacted to 20 gyrations. If the sample height is not 70 +/- 5 mm, the recycled asphalt mass shall be adjusted.

2.6 After compaction, the samples shall be removed from the compaction mold and placed on a flat pan to cure at the specified temperature and humidity (if required) for 4 hours +/- 5 minutes. The temperature shall be maintained at +/- 2 C from the temperature specified and the humidity (if required) shall be maintained at +/-10% from the number specified.

2.7 The specimens shall be weighed after the curing, just prior to testing.

2.8 The specimens shall be placed on the raveling test apparatus. Care shall be taken that the specimen is centered and well supported. The area of the hose in contact with the specimen shall not have been previously used. The hose may be rotated to an unworn section for testing. The abrasion head with hose shall be free to move vertically downward a minimum of 5 mm if abrasion allows.

2.9 The samples shall be abraded for 15 minutes and immediately weighed.

2.10 The percent raveling loss shall be determined as follows:

((Mass Prior to Test – Mass After Abrasion)/Mass Prior to Test) x 100.

2.11 The average of the two specimens shall be reported as the percent raveling loss. There shall not be a difference of 0.5 percent raveling loss between the two test specimens for proper precision. A difference of more than 0.5 percent will require the test to be repeated. If both of the samples have a raveling loss greater than 10 percent, the numbers shall be averaged and the precision rule will be waived.